CHAPTER 8

OVERLAP IN EDUCATIONAL PREPARATION

One of the overarching concerns of the Title Act Study is the amount of overlap in education and job experience of the separate disciplines. Are there sufficient commonalities to justify generic licensing of engineers, as is done in most states, with specialties identified by the type of engineering degree and subsequent work experience or asserted by self-certification? Or, if the commitment to discipline-based licensing is strong, are there sufficient commonalities to eliminate the practice/title distinction and license all disciplines as equal practice act disciplines?

In this report, the overlap issue is being addressed through the analysis of the educational requirements for branches of engineering taught in California universities and through the amount of overlap in NCEES licensing examinations. Overlap in the occupational analyses could not be addressed because of differing methodologies in the collection of this information and the unavailability of data for many disciplines. Since NCEES exams are based on the occupational analyses, analyzing exam outlines offers the most reasonable substitution. This chapter describes the amount of overlapping educational requirements in degree programs at seven California universities. Chapter 10 describes the amount of overlapping exam content using the evaluations of a sample of licensed engineers.

Educational Programs Supporting Regulated and Unregulated Engineering Disciplines

Using the number of 2000 graduates from the 30 California engineering schools, seven universities, accounting for 55% of all engineering graduates, were chosen for the analysis of educational requirements. These schools include: California State Polytechnic University, Pomona; California Polytechnic State University, San Luis Obispo; California State University, San Jose; University of California, Berkeley; University of California, Los Angeles; University of Southern California; and Stanford University. There are 142 Accreditation Board for Engineering and Technology (ABET) accredited engineering programs on the 30 campuses, of which 105 (or 74%) were in the regulated disciplines. The selected schools accounted for 37% of the undergraduate engineering degree programs in the state and 39% of those in the regulated disciplines. Control systems and structural engineering are the only regulated disciplines that lack an undergraduate degree program at the selected schools. In fact, a school not selected for inclusion -- UC San Diego -- offers the only Bachelor's degree program in structural engineering in the state. None of the universities offer an undergraduate degree in control systems. (Table 8.1)

The practice act disciplines are supported by 74 (or 52%) accredited programs throughout the state; all three are offered at each of the seven selected schools. Six title act disciplines are supported by 28 undergraduate programs (or 20%) throughout the state. Chemical and industrial are taught at six of the seven campuses, materials engineering at three, manufacturing at two, and agricultural and nuclear engineering each at a single campus. (Table 8.1) Most or all (75 % to 100%) of the accredited programs in agricultural, industrial, manufacturing, materials and nuclear engineering are offered at the included schools. Between 25% and 46% of accredited programs in the more commonly taught disciplines (chemical, civil, electrical, and mechanical) are found at the seven schools. (Table 8.1)

Options, specializations, or concentrations within majors are another way in which knowledge supporting a particular discipline is transmitted. Options within majors are less important for the

practice act disciplines because these are strongly supported by degree programs (44% vs. 52% of degree programs). They are more important for the title act and unregulated disciplines: 27% of the options support title act disciplines, compared with 20% of the degree programs while 29% of the options support unregulated disciplines compared with 25% of degree programs. (Table 8.2) The unregulated disciplines include aerospace, bio- and biomedical, computer, environmental, and management science engineering. (Table 8.3 - 8.5)

Some of the disciplines lacking undergraduate degree programs are supported by graduate degrees at the selected schools. A graduate degree in control systems is offered at six of the seven schools; structural engineering is offered at five, geotechnical at four and transportation engineering at three. Thus, both title authorities and two additional title acts (transportation and control systems) are supported at the graduate level. (Table 8.6)

Degree Requirements

To analyze degree requirements, quarter units were converted to semester units for comparability across institutions. In summarizing the units involved in the undergraduate majors and concentrations, five regulated disciplines were identified (geotechnical, structural, control systems, fire protection and traffic) that are not directly supported— except through limited concentrations— by the undergraduate degree programs at the selected schools. Structural, geotechnical and traffic engineering are treated as specializations within the civil engineering major with an average of 18 units for structural and 13.5 units for the other two sub-disciplines. Control systems is a 13.25 unit specialization within either an electrical engineering or mechanical engineering major. Fire protection is taught at a single location in the U.S., outside California. (Table 8.7)

Non-general education units for an engineering degree vary from a low of 78 at Stanford to a high of 106 at SLO. Degree units are highly variable within some schools -- Berkeley's engineering degree programs vary between 89 and 115 units -- but virtually unvarying within others. All but one program at Pomona requires 89 units; the exception requires 92. Engineering course units also vary by school and discipline. Stanford requires the fewest units in engineering courses (43.9) and SLO the most (68.7). With the exception of Stanford and Berkeley (43.9 and 54.6 units on average), the schools' engineering course units vary between 61.6 (UCLA) and 68.7 (SLO and San Jose). The seven schools require more units in the practice act disciplines than they do in the title act disciplines (64 vs. 57.7). (Table 8.8)

The seven engineering schools varied in the number of degree programs offered in the regulated disciplines. Berkeley offered the greatest variety of engineering degrees (9), with only agriculture excluded. USC and UCLA offered the fewest (5). With the exception of Stanford and Berkeley, the units required for specific degrees are reasonably consistent across the campuses. Degrees in manufacturing, civil and mechanical engineering have the highest engineering course unit requirement (67, 66 and 65 units respectively) while chemical and petroleum engineering have the lowest (51.7 and 51.5 units). The dependence of chemical and petroleum engineering on basic chemistry and its inclusion in support units for all engineering degrees may contribute to the lower number of engineering units for degrees in these two fields. (Table 8.8)

Engineering students must take both engineering coursework as well as supporting classes that are not based in engineering and are not general education courses. Non-general education courses include courses in support subjects such as physics, chemistry and math. The universities vary in the emphasis placed on support units in physics, chemistry and math. An

engineering degree at Berkeley, Stanford and UCLA includes more units in these basic subjects, as a proportion of all non-general education units, than the CSU campuses and USC. Physics, chemistry and math make up between 40% and 55% of non-general education units required for the degree at Berkeley, Stanford and UCLA; they make up between 28% and 35% at the CSU campuses and 37% at USC. (Table 8.8)

Many engineering degrees provide for specializations within the degree and, as noted above, these specializations provide the only support at the undergraduate level for the two title authorities and three title act disciplines (control systems, fire protection and traffic). Options, emphases, concentrations or specializations, which are interchangeable terms, require between 11 and 18 units on average, although the range for individual programs varies from 6 to 24. Only two of the regulated disciplines are supported by concentrations at the high end of this range (industrial with a single program requiring 19 units and structural with 4 programs averaging an 18 unit specialization). One school offers a 16-unit materials science minor. The remaining concentrations average 11 to 13.5 units. (Table 8.7)

Educational Overlap

One indicator of the degree of similarity among engineering disciplines is the amount of shared coursework in their undergraduate degree programs. Detailed information on specific course requirements for the engineering degree programs summarized in Table 8.8 was analyzed for the amount of overlap in engineering and support area units. The amount of overlap by school and program is summarized in Tables 8.9, 8.10 and 8.11.

This analysis is thought to be conservative because, for organizational reasons, universities seek to distinguish majors from each other as much as possible. This would have the effect of understating the amount of overlap between disciplines. It is the most "objective" measure of overlap because there is no interpretation or grouping of courses into subject matter categories. Units allocated to specific required and elective courses are counted as overlapping when different degree programs identify the same course requirements by department and course number, title or course description.

The greatest amount of educational overlap occurs between industrial and manufacturing engineering. They share two-thirds (68%) of all non-general education courses (ranging between 64% and 71% at the three schools offering both degrees) and well over half (57%) of all engineering courses (ranging between 55% and 59%). (Table 8.11) Manufacturing and mechanical engineering are ranked second in terms of shared engineering units and third in terms of all engineering and support units, with 51% of all non-general education units in common and 38% of all engineering units in common.

The rankings and average percents are influenced by significant differences among the schools in the amount of overlapping units for some programs. Mechanical and manufacturing engineering are very similar at Berkeley, with 66% of all units and 56% of engineering units in common. They are more distinguished from each other at Pomona and SLO, with 39% and 49% respectively of all units and 25% and 33% of engineering units in common. This variability is expressed by the larger standard deviation (SD=13%) for the proportion of shared units between these majors. Other combinations with more inter-campus variability in the proportion of overlapping units include: chemical and petroleum (SD = 24%), chemical and metallurgical (11%), manufacturing and metallurgical (11%), and civil and metallurgical and civil and mechanical (10% each). Berkeley makes more of a distinction between the chemical and petroleum engineering majors, with 20% of all units and 17% of engineering units in common,

than Stanford does, with 55% of all units and 45% of engineering units in common. If overlap were judged on the basis of the Stanford program, chemical and petroleum engineering would rank second in overlapping units. Thus, the variability between universities affects the ranking of overlap among engineering disciplines. (Table 8.10)

Metallurgical engineering is involved in three of the six combinations of majors with the greatest variability in overlapping units. Stanford and Berkeley are partially responsible for this variability because of their high percentages of overlap in all non-general education and engineering units for metallurgical with chemical, civil and mechanical engineering. Metallurgical engineering shares over half of all units with civil (55%) and mechanical (56 - 57%) and almost half of all units (45%) with chemical at these two schools. It also shares over half of all units (56%) with chemical at Pomona and San Jose. It is Berkeley that increases the variability in the metallurgical/chemical combination because of its lower proportion of overlapping courses (30%). Metallurgical engineering also shares 57% of all units with manufacturing at SLO, but a much lower percentage at Pomona and Berkeley. Whether these differences reflect different perceptions of the fields or different emphases within them, or fiscal decisions to support some programs more than others is impossible to tell. (Table 8.10)

Another aspect of overlapping educational requirements is whether the overlap for all units is largely due to overlap in engineering or support area courses. For example, most of the overlap between industrial and manufacturing engineering is in the engineering units rather than the support courses (57% out of the 68% of all overlapping units are in engineering, a ratio of 84%). In general, the combinations with more engineering units are those where engineering units dominate all overlapping units. In the first four and the seventh combinations in Table 8.11, the proportion of overlapping units in engineering courses make up 75 - 85% of all overlapping units in non-general education courses. These combinations include: industrial and manufacturing, manufacturing and mechanical, and mechanical, chemical and manufacturing with petroleum. Other discipline pairings have more shared support units and fewer shared engineering units. For example, overlapping engineering coursework makes up barely half of all overlapping units between mechanical and nuclear (27% out of 52%). Other combinations with similarly low ratios include metallurgical with mechanical (28% out of 47% or 60%), chemical (60%), manufacturing (61%), and civil (52%) as well as civil with mechanical (50%). (Table 8.11)

Educational Background of Engineers

Using the job analysis data files where available and published job analysis reports when they weren't, the educational background of engineers licensed in the regulated fields were summarized in an effort to identify the type of degree that supports the regulated disciplines. Unfortunately, there is no consistency in the framing of questions regarding educational background and therefore the responses are difficult to interpret and compare. Some questionnaires ask for the highest educational level completed but offer different response categories (electrical, manufacturing, mechanical, metallurgical and petroleum vs. structural and traffic) while others ask for the highest engineering degree and its specialty (control systems and agricultural). Yet another variation asks for the specialty that best describes the Bachelor's degree (manufacturing and metallurgical). All three seek a single answer. Job analysis questionnaires in other disciplines (chemical, industrial, and civil) seek multiple responses to the question: "What educational degrees do you hold?" Although job analysis questionnaires typically restrict responses to registered or licensed engineers, small numbers of unregistered engineers responded to these questions. (Tables 8.12a, b, and e)

Most engineers have at least a Bachelor's degree. Significant proportions have graduate degrees (30% or more in all but petroleum and traffic engineers). (Tables 8.12a - d) Based on the job analysis surveys, more metallurgical, structural and agricultural engineers have graduate degrees in engineering than any other disciplines studied (74%, 57% and 56% respectively). (Tables 8.12a-d).

The number of programs available in various disciplines undoubtedly influences the educational background that leads into an area of practice. For example, only three of the seven schools selected for study in California offer degrees in manufacturing. This may not be unusual nationally since almost half (46.5%) of manufacturing engineers have degrees in mechanical engineering and only 8.2% have degrees in manufacturing. (Table 8.12e) In contrast, six of California's seven selected schools offer degrees in metallurgical engineering, and nationally, 65.8% of metallurgical engineers have degrees in metallurgical engineering. Other common backgrounds for metallurgical engineers are chemical and materials engineering (8.6% each). (Table 8.12e) Similarly, control systems engineers are most often educated in electrical (42.2%), mechanical (21.1%) and chemical (14.2%) engineering. Only 9% of control systems engineers nationwide have a specialty in control systems associated with their highest engineering degree. (Table 8.12f)

Most (76% or more) agricultural, chemical, civil, electrical, mechanical and metallurgical engineers have Bachelor's degrees from an ABET-accredited program. Somewhat fewer, but still a solid majority, of industrial (70%), manufacturing (65%) and petroleum (60%) engineers graduated from ABET accredited programs. (Table 8.13)

Table 8.1. ABET Accredited Engineering Programs in California (Accreditation Period Ending September 30, 2001)

		Cal Poly		California State University											University of California																7 Study Schools	
	Caltech	SLO	Pomona	Chico	Fresno	Fullerton	Humboldt	Long Beach	Los Angeles	Northridge	Sacramento	San Diego	San Francisco	San Jose	Berkeley	Davis	Irvine	Los Angeles	Riverside	San Diego	Santa Barbara	Santa Cruz	Harvey Mudd	Loyola Marymount	NPS	UOP	Univ. of San Diego	Santa Clara Univ.	USC	Stanford	Total # of Programs	# of Programs	% of Programs
Aeronautical Engineering																									✓						1	0	0%
Aeronautical Science and Engineering																✓															1	0	0%
Aerospace Engineering		✓	✓									✓		✓			✓	✓											✓		7	5	71%
Architectural Engineering		✓																													1	1	100%
Astronautical Engineering																									✓						1	0	0%
Bioengineering																				✓											1	0	0%
Biological Systems Engineering																✓															1	0	0%
BioResource and Agriculture Engineering		✓	--											--	--			--											--	--	1	1	100%
Chemical Engineering	✓	--	✓					✓						✓	✓	✓	✓	✓	✓	✓	✓								✓	✓	13	6	46%
Civil & Environmental Engineering															✓																21	7	33%
Civil Engineering		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓						✓		✓		✓	✓	✓			
Computer Engineering		✓		✓				✓			✓			✓		✓	✓					✓				✓		✓			10	2	20%
Computer Science & Engineering															✓	✓		✓								✓					3	2	67%
Electrical and Electronic(s) Engineering											✓																						
Electrical Engineering	✓	✓	✓		✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓	28	7	25%
Electrical Engineering/Materials Science and Engineering																✓																	
Electrical/Electronic(s) Engineering				✓																													
Engineering										✓													✓								2	0	0%
Engineering and Applied Science	✓																														1	0	0%
Engineering Physics																										✓					1	0	0%
Environmental Engineering		✓															✓		✓										✓		4	2	50%
Environmental Resources Engineering							✓																								1	0	0%
Geomatics Engineering					✓																										1	0	0%
Industrial & Systems Engineering														✓				--											✓		7	6	86%
Industrial Engineering		✓	✓		✓										✓			--												✓			
Manufacturing Engineering		✓	✓											--	⊘			--											--	--	2	2	100%
Materials Engineering		✓	⊘											✓				✓													4	3	75%
Materials Science & Engineering															⊘	✓														⊘			
Mechanical Engineering		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓	✓	25	7	28%
Mechatronics Engineering				✓																											1	0	0%
Nuclear Engineering		--	--											--	✓			--											--	--	1	1	100%
Structural Engineering		--	--											--	--			--		✓									--	--	1	0	0%
Surveying Engineering		--	--		✓									--	--			--											--	--	2	1	50%
Surveying Option in Civil Engineering		--	✓											--	--			--											--	--			
Total for Regulated Disciplines	2	7	7	3	5	3	0	4	3	3	3	3	3	6	6	6	4	5	3	4	3	0	0	3	2	3	1	3	5	5	105	41	39%
Total for All Disciplines	3	11	8	5	6	3	1	5	3	4	4	4	3	8	7	10	7	7	4	5	3	1	1	3	4	5	1	4	7	5	142	53	37%

Note: The seven study schools and disciplines regulated in California are shaded. The symbol "✓ " is used to indicate that a program is accredited. For study schools, the symbol "⊘" is used to indicate that a program is not accredited and "—" is used to indicate the school does not offer a program in that discipline.

Table 8.2 Summary of Undergraduate Options/Specializations/Concentrations

	Pomona	SLO	San Jose	Stanford	Berkeley	UCLA	USC	Total	Percent
Options/Specializations/Concentrations in Disciplines Not Regulated in California	5	8	8	10	9	3	12	55	29.3
Options/Specializations/Concentrations in California Practice Act Disciplines	15	9	8	9	11	7	24	83	44.1
Options/Specializations/Concentrations in California Title Act Disciplines	4	8	3	9	11	7	8	50	26.6
Total	24	25	19	28	31	17	44	188	100.0

Table 8.3. Undergraduate Options/Specializations/Concentrations in Disciplines *Not Regulated* in California

Degree	Option/Specialization/Concentration	Pomona	SLO	San Jose	Stanford	Berkeley	UCLA	USC
Aeronautics and Astronautics					✓			
Aerospace Engineering	General	✓					✓	✓
	Aerodynamics and Propulsion			✓				
	Aeronautic		✓					
	Astronautics		✓					✓
	Dynamics and Control			✓				
	Structures			✓				
Applied Mechanics								✓
Bioengineering (areas of specialization under review)						✓		
Biomedical Engineering	General							✓
	Biochemical Engineering							✓
Computational Engineering Science						✓		
Computer Engineering			✓	✓				
Computer Engineering and Computer Science	Advanced Circuit Design							✓
	Multimedia and Graphics							✓
	Software Systems							✓
	Theory							✓
Computer Science	General		✓		✓		✓	✓
	Manufacturing Engineering							✓
Computer Science and Engineering	General						✓	
	Computer Science (Option IV)					✓		
Computer Systems Engineering					✓			
Construction Engineering Technology		✓						
Earth Resource Engineering	General					✓		
	Environmental Engineering					✓		
	Mineral Engineering					✓		
Electronics and Computer Engineering Technology		✓						
Engineering Mathematics and Statistics						✓		
Engineering Physics						✓		
Engineering Technology	Environmental	✓						
	General Mechanical & Manufacturing	✓						
Environmental Engineering			✓		✓			✓
Environmental Engineering Science						✓		
General Engineering	General			✓				
	Bioengineering		✓					
	Biomedical Engineering		✓					
	Environmental Health & Safety Engineering			✓				
	Individualized Course of Study		✓					
	Microelectronics Process Engineering			✓				
	Software and Information Engineering			✓				
Management Science and Engineering	Financial and Decision Engineering				✓			
	Operations Management				✓			
	Operations Research				✓			
	Technology and Organizations				✓			
	Technology and Policy				✓			
Product Design					✓			

Table 8.4. Undergraduate Options/Specializations/Concentrations in California *Practice Act* Disciplines

Discipline	Degree	Option/Specialization/Concentration		Pomona	SLO	San Jose	Stanford	Berkeley	UCLA	USC
Civil Engineering	Civil Engineering	General Civil Engineering		✓	✓	✓		✓	✓	✓
		Building Science								✓
		Construction Engineering								✓
		Construction Engineering and Management						✓		
		Environmental and Water Resources Engineering				✓				
		Environmental and Water Studies					✓			
		Environmental Engineering		✓				✓		✓
		GeoEngineering						✓		
		Geotechnical			✓					
		Structural Engineering			✓			✓		✓
		Structural Engineering and Applied Mechanics				✓				
		Structures and Construction					✓			
		Surveying Engineering		✓						
		Transportation			✓			✓		
		Transportation, Construction & Geotechnical Engineering				✓				
		Water Resources Engineering			✓					✓
Electrical Engineering	Electrical and Computer Engineering	Communications, Networks and Systems (Option II)						✓		
		Computer Systems (Option III)						✓		
		Electronics (Option I)						✓		
		General (Option V)						✓		
	Electrical Engineering	General				✓			✓	
		Biomedical Engineering							✓	
		Communication and Signal Processes		✓						
		Communication, Control and Signal Processing	Control Systems							✓
			Digital Signal Processing							✓
			Modern Communication Systems							✓
			Robotics							✓
			Systems							✓
			Communication Networks							✓
		Computer Engineering							✓	
		Computer Engineering	Computer Architecture and Organization							✓
			Computer Networks							✓
			Hardware/Software							✓

Note: Shaded areas indicate programs that will be included in coursework analysis.

Table 8.4. (Continued) Undergraduate Options/Specializations/Concentrations in California *Practice Act* Disciplines

Discipline	Degree	Option/Specialization/Concentration		Pomona	SLO	San Jose	Stanford	Berkeley	UCLA	USC
Electrical Engineering (continued)	Electrical Engineering (continued)	Computer Hardware					✓			
		Computer Software					✓			
		Computer Systems		✓						
		Computers								✓
		Control and Robotic		✓						
		Controls					✓			
		Electromagnetics and Energy Conversion	Energy Conversion							✓
			Energy Conversion: Lasers							✓
		Electronic			✓					
		Electronic Devices and Circuits	Electronic Circuits							✓
			Integrated Circuits							✓
		Electronics					✓			
		Fields and Waves					✓			
		General SPE		✓						
		Illumination Engineering		✓						
		Instrum. Biomed Ocean		✓						
		Manufacturing Engineering								✓
		Microelectronics		✓						
		Power			✓					
		Power Systems		✓						
		Radio Frequency Systems		✓						
		Signal Processing and Communication					✓			
Mechanical Engineering	Mechanical Engineering	General		✓	✓		✓	✓		✓
		Design and Manufacturing							✓	
		Dynamics and Control							✓	
		Energy (Thermal/Fluid Sciences)		✓						
		Fluids and Thermal Engineering							✓	
		Manufacturing Engineering								✓
		Mechanical Design		✓		✓				
		Mechatronics			✓	✓				
		Petroleum Engineering								✓
		Thermal/Fluids				✓				

Note: Shaded areas indicate programs that will be included in coursework analysis.

Table 8.5. Undergraduate Options/Specializations/Concentrations in California *Title Act* Disciplines

Discipline	Degree	Option/Specialization/Concentration	Pomona	SLO	San Jose	Stanford	Berkeley	UCLA	USC
Agricultural	BioResource & Agricultural Engineering			✓					
Chemical	Chemical Engineering	General	✓		✓	✓		✓	✓
		Applied Chemistry					✓		
		Applied Physics					✓		
		Biochemical Engineering							✓
		Bioengineering						✓	
		Biomedical Engineering						✓	
		Biotechnology					✓		
		Chemical Processing					✓		
		Environmental						✓	
		Environmental Engineering							✓
		Environmental Technology					✓		
		Manufacturing Engineering							✓
		Materials Science					✓		
		Petroleum Engineering							✓
		Polymer Science							✓
		Semiconductor Manufacturing						✓	
Industrial	Industrial and Systems Engineering	General			✓				✓
		Manufacturing Engineering							✓
	Industrial Engineering		✓	✓					
	Industrial Engineering and Operations Research						✓		
	Management Science and Engineering	Industrial Engineering				✓			
Manufacturing	Manufacturing Engineering	General	✓	✓			✓		
		Manufacturing Process Engineering		✓					
		Manufacturing Systems		✓					
		Mechatronics Manufacturing		✓					
		Metrology		✓					
Metallurgical	Materials Engineering	General	✓	✓	✓			✓	
		Electronic Materials						✓	
	Materials Science and Engineering	General					✓		
		Chemical Engineering				✓			
		Chemistry				✓			
		Electrical Engineering				✓			
		Mechanical Engineering				✓			
		Physics				✓			
		Self-Defined Option				✓			
Nuclear	Nuclear Engineering						✓		
Petroleum	Earth Resource Engineering	Petroleum Engineering					✓		
	Petroleum Engineering					✓			

Note: Shaded areas indicate programs that will be included in coursework analysis. This table includes some degree programs that are not accredited.

Table 8.6 Summary of Selected Graduate Program Specializations**

	Pomona	SLO	San Jose	Stanford*	Berkeley*	UCLA	USC	Total
Structural	1		1	1	1	1		5
Geotechnical			1	1	1	1		4
Transportation		1	1		1			3
Control Systems	1		1		1	2	1	6

* Numbers for Geotechnical include a Geomechanics program at Stanford and a Geoengineering program at Berkeley.

** For complete listing of Graduate program specializations see Appendix G.

Table 8.7. Undergraduate Engineering Degree Programs and Specialties* at Seven Study Schools by Discipline and Type of Regulation

Type of Regulation	Discipline	Number of Schools Offering Degree in Discipline	Total Units Required in Engineering Topics**	Number of Specialties in Regulated Disciplines	Description of Specialty Area	Units Required in Specialty Area**	
						Average	Range
Practice Act	Civil	7	65.6	0			
	Geotechnical	0	--	2	Specialization for Civil Engineering majors	13.5	12-15
	Structural	0	--	4	Specialization/emphasis for Civil Engineering majors	18	12-24
	Electrical	7	61.3	1	Option for Material Science Engineering majors	6	--
	Mechanical	7	65.1	1	Option for Material Science Engineering majors	6	--
Title Act	Agriculture	1	62.0	0			
	Chemical	6	51.7	1	Option for Material Science Engineering majors	6	--
	Control	0	--	4	Specialty/certificate for Electrical or Mechanical Engineering majors	13.25	7-22
	Fire Protection	0	--	0			
	Industrial	5	59.8	1	Concentration for Management Science Engineering majors	19	--
	Manufacturing	3	67.3	2	Specialization/emphasis for various Engineering majors	11	8-14
	Metallurgical	6	56.8	1	Materials Science minor with various Engineering majors	16	--
	Nuclear	1	55.0	0			
	Petroleum***	3	51.5	1	Option for Earth Resources Engineering majors	17	--
	Traffic	0	--	2	Specialization for Civil Engineering majors	13.5	12-15

* The term specialty is used in this table to describe options, concentrations and areas of emphasis.

** Units from Universities on quarter systems have been converted to semester units.

*** For the sake of completeness degree programs in petroleum engineering are included in the table even though they are not ABET accredited.

Table 8.8. Units Required for Engineering Degrees by School

		Pomona	SLO	San Jose	Stanford	Berkeley	UCLA	USC	Average
All Units (Excluding General Education Courses)	Agricultural	--	105	--	--	--	--	--	105.0
	Chemical	89	--	102	89	115	108	105	101.3
	Civil	89	108	106	77	94	98	104	96.6
	Electrical	92	104	103	78	96	104	106	97.6
	Industrial	89	107	98	76	89	--	102	93.5
	Manufacturing	89	106	--	--	99	--	--	73.5
	Mechanical	89	107	102	74	89	106	103	95.7
	Metallurgical	89	105	98	75	115	99	--	96.8
	Nuclear	--	--	--	--	91	--	--	91.0
	Petroleum	--	--	--	76	104	--	--	90.0
	Average	89.4	106.0	101.5	78.0	99.0	103.0	104.0	
Engineering Course Units	Agricultural	--	62	--	--	--	--	--	62.0
	Chemical	57	--	58	38	53	51	53	51.6
	Civil	70	70	76	49	60	62	72	65.6
	Electrical	70	68	73	43	44	65	66	61.3
	Industrial	59	72	69	45	51	--	63	59.8
	Manufacturing	68	70	--	--	64	--	--	67.3
	Mechanical	67	71	72	48	57	69	72	65.1
	Metallurgical	60	68	64	46	42	61	--	56.8
	Nuclear	--	--	--	--	55	--	--	55.0
	Petroleum[a]	--	--	--	38	65	--	--	51.5
	Average	64.4	68.7	68.7	43.9	54.6	61.6	65.2	
Average Supporting Units[b]		25.0	37.3	32.8	34.1	44.4	41.4	38.8	
Average % Supporting Units[c]		28.0	35.2	32.3	43.7	54.6	40.2	37.0	
Average Number of Engineering Units for Degrees Supporting Title Act Disciplines[d]									57.7
Average Number of Engineering Units for Degrees Supporting Practice Act Disciplines[e]									64.0

[a] For the sake of completeness degree programs in petroleum engineering are included in the table even though they are not ABET accredited.

[b] Supporting Units are the number on non-general education units required other than engineering units.

[c] Average percent of Supporting Units is equal to the average number of supporting units divided by the average number of all non-general education units.

[d] Degrees supporting Title Act Disciplines are Agricultural, Chemical, Industrial, Manufacturing, Metallurgical, Nuclear, and Petroleum.

[e] Degrees supporting Practice Act Disciplines are Civil, Electrical, and Mechanical.

Table 8.9. Overlapping Units (Excluding General Education Courses) Required for Engineering Degrees by School

		All Units							Engineering Units						
Degrees		Pomona	SLO	San Jose	Stanford	Berkeley	UCLA	USC	Pomona	SLO	San Jose	Stanford	Berkeley	UCLA	USC
Agricultural	Civil		46							11					
Agricultural	Electrical		37							7					
Agricultural	Industrial		43							8					
Agricultural	Manufacturing		44							10					
Agricultural	Mechanical		39							9					
Agricultural	Metallurgical		44							10					
Chemical	Civil	20		35	34	27	45	35	2		14	11	0	10	4
Chemical	Electrical	19		32	27	28	34	35	0		11	2	0	2	3
Chemical	Industrial	27		33	37	30		31	7		12	10	6		4
Chemical	Manufacturing	25				34			5				10		
Chemical	Mechanical	24		35	36	38	45	27	5		14	13	10	10	0
Chemical	Metallurgical	50		56	37	34	47		26		23	11	6	11	
Chemical	Nuclear					37							9		
Chemical	Petroleum				45	22						17	10		
Civil	Electrical	17	37	35	22	27	43	43	0	9	9	2	0	11	13
Civil	Industrial	23	47	41	34	28		31	4	13	14	13	0		8
Civil	Manufacturing	31	52			33			11	17			5		
Civil	Mechanical	27	46	53	41	36	57	33	11	16	28	16	5	22	3
Civil	Metallurgical	28	49	38	42	40	54		10	16	14	16	6	21	
Civil	Nuclear					37							3		
Civil	Petroleum				28	31						9	12		
Electrical	Industrial	21	36	38	24	30		30	2	8	12	3	6		5
Electrical	Manufacturing	19	39			24			0	11			0		
Electrical	Mechanical	17	37	39	20	31	47	34	0	11	9	3	3	15	3
Electrical	Metallurgical	19	40	39	22	28	41		0	9	14	2	0	11	
Electrical	Nuclear					31							3		
Electrical	Petroleum				17	15						0	3		
Industrial	Manufacturing	57	76			65			35	41			34		
Industrial	Mechanical	29	43	42	35	37		24	11	13	16	15	9		1
Industrial	Metallurgical	31	49	37	37	31			11	15	12	13	3		
Industrial	Nuclear					35							7		
Industrial	Petroleum				28	28						7	12		
Manufacturing	Mechanical	35	52			62			17	23			34		
Manufacturing	Metallurgical	35	60			39			14	26			11		
Manufacturing	Nuclear					37							9		
Manufacturing	Petroleum					34							18		
Mechanical	Metallurgical	36	48	39	42	43	58		17	16	14	18	11	25	
Mechanical	Nuclear					47							15		
Mechanical	Petroleum				33	36						13	20		
Metallurgical	Nuclear					46							10		
Metallurgical	Petroleum				29	35						8	15		
Nuclear	Petroleum					35							15		

Table 8.10. Percent Overlap by School*

		All Units								Engineering Units							
Degrees		Pomona	SLO	San Jose	Stanford	Berkeley	UCLA	USC	Average	Pomona	SLO	San Jose	Stanford	Berkeley	UCLA	USC	Average
Agricultural	Civil		43%						43%		17%						17%
Agricultural	Electrical		35%						35%		11%						11%
Agricultural	Industrial		41%						41%		12%						12%
Agricultural	Manufacturing		42%						42%		15%						15%
Agricultural	Mechanical		37%						37%		14%						14%
Agricultural	Metallurgical		42%						42%		15%						15%
Chemical	Civil	22%		34%	41%	26%	44%	33%	33%	3%		21%	25%	0%	18%	6%	12%
Chemical	Electrical	21%		31%	32%	27%	32%	33%	29%	0%		17%	5%	0%	3%	5%	5%
Chemical	Industrial	30%		33%	45%	29%		30%	34%	12%		19%	24%	12%		7%	15%
Chemical	Manufacturing	28%				32%			30%	8%				17%			13%
Chemical	Mechanical	27%		34%	44%	37%	42%	26%	35%	8%		22%	30%	18%	17%	0%	16%
Chemical	Metallurgical	56%		56%	45%	30%	45%		46%	44%		38%	26%	13%	20%		28%
Chemical	Nuclear					36%			36%					17%			17%
Chemical	Petroleum				55%	20%			37%				45%	17%			31%
Civil	Electrical	19%	35%	33%	28%	28%	43%	41%	33%	0%	13%	12%	4%	0%	17%	19%	9%
Civil	Industrial	26%	44%	40%	44%	31%		30%	36%	6%	18%	19%	28%	0%		12%	14%
Civil	Manufacturing	35%	49%			34%			39%	16%	24%			8%			16%
Civil	Mechanical	30%	43%	51%	54%	39%	56%	32%	44%	16%	23%	38%	33%	9%	34%	4%	22%
Civil	Metallurgical	31%	46%	37%	55%	38%	55%		44%	15%	23%	20%	34%	12%	34%		23%
Civil	Nuclear					40%			40%					5%			5%
Civil	Petroleum				37%	31%			34%				21%	19%			20%
Electrical	Industrial	23%	34%	38%	31%	32%		29%	31%	3%	11%	17%	7%	13%		8%	10%
Electrical	Manufacturing	21%	37%			25%			28%	0%	16%			0%			5%
Electrical	Mechanical	19%	35%	38%	26%	34%	45%	33%	33%	0%	16%	12%	7%	6%	22%	4%	10%
Electrical	Metallurgical	21%	38%	39%	29%	27%	40%		32%	0%	13%	20%	4%	0%	17%		9%
Electrical	Nuclear					33%			33%					6%			6%
Electrical	Petroleum				22%	15%			19%				0%	6%			3%
Industrial	Manufacturing	64%	71%			69%			68%	55%	58%			59%			57%
Industrial	Mechanical	33%	40%	42%	47%	42%		23%	38%	17%	18%	23%	32%	17%		1%	18%
Industrial	Metallurgical	35%	46%	38%	49%	30%			40%	18%	21%	18%	29%	6%			19%
Industrial	Nuclear					39%			39%					13%			13%
Industrial	Petroleum				37%	29%			33%				17%	21%			19%
Manufacturing	Mechanical	39%	49%			66%			51%	25%	33%			56%			38%
Manufacturing	Metallurgical	39%	57%			36%			44%	22%	38%			21%			27%
Manufacturing	Nuclear					39%			39%					15%			15%
Manufacturing	Petroleum					33%			33%					28%			28%
Mechanical	Metallurgical	40%	45%	39%	56%	42%	57%		47%	27%	23%	21%	38%	22%	38%		28%
Mechanical	Nuclear					52%			52%					27%			27%
Mechanical	Petroleum				44%	37%			41%				30%	33%			32%
Metallurgical	Nuclear					45%			45%					21%			21%
Metallurgical	Petroleum				38%	32%			35%				19%	28%			24%
Nuclear	Petroleum					36%			36%					25%			25%

* Percent overlap was computed by dividing the sum of units for courses required for both degrees by the average number units required for the two degrees (excluding general education course requirements).

Table 8.11 Percent Overlap (in Rank Order for Engineering Units)

		# of Schools Offering Both Degrees	All Units		Engineering Units		Rank		Percent of Engineering Units per Total Units
			Average	SD	Average	SD	All Units	Engineering Units	
Industrial	Manufacturing	3	68%	4%	57%	2%	1	1	84%
Manufacturing	Mechanical	3	51%	13%	38%	16%	3	2	75%
Mechanical	Petroleum	2	41%	5%	32%	2%	13	3	78%
Chemical	Petroleum	2	37%	24%	31%	20%	21	4	84%
Mechanical	Metallurgical	6	47%	8%	28%	8%	4	5	60%
Chemical	Metallurgical	5	46%	11%	28%	13%	5	6	61%
Manufacturing	Petroleum	1	33%		28%		31	7	85%
Mechanical	Nuclear	1	52%		27%		2	8	52%
Manufacturing	Metallurgical	3	44%	11%	27%	9%	7	9	61%
Nuclear	Petroleum	1	36%		25%		24	10	69%
Metallurgical	Petroleum	2	35%	5%	24%	6%	27	11	69%
Civil	Metallurgical	6	44%	10%	23%	9%	8	12	52%
Civil	Mechanical	7	44%	10%	22%	13%	9	13	50%
Metallurgical	Nuclear	1	45%		21%		6	14	47%
Civil	Petroleum	2	34%	4%	20%	1%	29	15	59%
Industrial	Petroleum	2	33%	6%	19%	3%	34	16	58%
Industrial	Metallurgical	5	40%	8%	19%	8%	16	17	48%
Industrial	Mechanical	6	38%	8%	18%	10%	20	18	47%
Agricultural	Civil	1	43%		17%		10	19	40%
Chemical	Nuclear	1	36%		17%		23	19	47%
Civil	Manufacturing	3	39%	8%	16%	8%	17	21	41%
Chemical	Mechanical	6	35%	8%	16%	11%	28	22	46%
Agricultural	Metallurgical	1	42%		15%		11	23	36%
Agricultural	Manufacturing	1	42%		15%		12	24	36%
Manufacturing	Nuclear	1	39%		15%		18	25	38%
Chemical	Industrial	5	34%	6%	15%	7%	30	26	44%
Civil	Industrial	6	36%	8%	14%	10%	25	27	39%
Agricultural	Mechanical	1	37%		14%		22	28	38%
Industrial	Nuclear	1	39%		13%		19	29	33%
Chemical	Manufacturing	2	30%	3%	13%	6%	39	30	43%
Chemical	Civil	6	33%	8%	12%	10%	32	31	36%
Agricultural	Industrial	1	41%		12%		14	32	29%
Agricultural	Electrical	1	35%		11%		26	33	31%
Electrical	Industrial	6	31%	5%	10%	5%	38	34	32%
Electrical	Mechanical	7	33%	8%	10%	8%	35	35	30%
Civil	Electrical	7	33%	8%	9%	8%	36	36	27%
Electrical	Metallurgical	6	32%	8%	9%	9%	37	37	28%
Electrical	Nuclear	1	33%		6%		33	38	18%
Electrical	Manufacturing	3	28%	8%	5%	9%	41	39	18%
Civil	Nuclear	1	40%		5%		15	40	13%
Chemical	Electrical	6	29%	5%	5%	6%	40	41	17%
Electrical	Petroleum	2	19%	5%	3%	4%	42	42	16%

Table 8.12a. Educational Degrees Held by Chemical, Civil, Electrical, Industrial, Manufacturing, Mechanical, Metallurgical and Petroleum Engineers

	Chemical[ac]		Civil[c]		Electrical[b]		Industrial[a]		Manufacturing[b]		Mechanical**		Metallurgical[b]		Petroleum[b]	
What educational degrees do you hold?	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Missing					*157*	8.7%			*22*	4.0%	*109*	6.4%			*71*	28.6%
No degree	*2*	.9%	*4*	0.6%	*7*	.4%	*4*	2.0%	*15*	2.7%	*8*	.5%				
Associate Degree	*8*	3.5%	*31*	4.4%	*5*	.3%	*15*	7.4%	*23*	4.2%	*5*	.3%			*2*	.8%
Four-Year Engineering Technology Degree	*3*	1.3%	*14*	2.0%	*20*	1.1%	*3*	1.5%	*20*	3.7%	*28*	1.6%				
Bachelor's Degree in Science-Related Field	*16*	7.0%	*45*	6.4%	*9*	.5%	*19*	9.3%	*19*	3.5%	*9*	.5%			*2*	.8%
Bachelor's Degree in Engineering	*182*	80.2%	*508*	72.6%	*859*	47.6%	*154*	75.5%	*168*	30.7%	*899*	52.7%	*39*	21.2%	*108*	43.6%
Master's Degree in Another Field	*28*	12.3%	*43*	6.1%	*130*	7.2%	*60*	29.4%	*91*	16.6%	*136*	8.0%	*8*	4.4%	*11*	4.4%
Master's Degree in Engineering	*70*	30.8%	*316*	45.1%	*467*	25.9%	*62*	30.4%	*108*	19.7%	*410*	24.1%	*40*	21.7%	*37*	14.9%
Doctorate in Another Field	*1*	.4%	*4*	0.6%	*11*	.6%	*3*	1.5%	*13*	2.4%	*12*	.7%	*4*	2.2%	*2*	.8%
Doctorate in Engineering	*21*	9.3%	*36*	5.1%	*125*	6.9%	*14*	6.9%	*59*	10.8%	*88*	5.2%	*93*	50.5%	*15*	6.0%
Other	*2*	.9%	*19*	2.7%	*14*	.8%	*1*	5.0%	*10*	1.8%	*1*	.1%				
Total	*227*	146.6%	*700*	145.7%	*1804*	100.0%	*204*	168.9%	*548*	100.0%	*1705*	100.0%	*184*	100.0%	*248*	100.0%

Table 8.12b. Highest Engineering Degree for Agricultural and Control Systems Engineers

	Agricultural		Control Systems	
Highest Engineering Degree	*N*	%	*N*	%
None	*7*	.7%	*28*	3.4%
Associate's	*3*	.3%	*21*	2.6%
Bachelor's	*400*	42.2%	*475*	58.2%
Master's	*261*	27.6%	*200*	24.5%
Doctorate	*269*	28.4%	*82*	10.0%
Did not respond	*7*	.7%	*10*	1.2%
Total	*947*	100.0%	*816*	100.0%

Table 8.12c. Highest Educational Level Completed by Traffic Engineers

	Traffic	
Highest Educational Level Completed	*N*	%
High school/some college	*26*	6.2%
BS in civil, transportation, or traffic engineering	*174*	41.6%
BS/BA in field other than civil, transportation, or traffic engineering	*36*	8.6%
MS in civil, transportation, or traffic engineering	*140*	33.5%
MS/MA in field other than civil, transportation, or traffic engineering	*25*	6.0%
Doctorate in engineering	*9*	2.2%
Doctorate in field other than engineering	*2*	.5%
No response	*6*	1.4%
Total	*418*	100.0%

Table 8.12d. Highest Level of Education for Structural Engineers

	Structural	
Highest Level of Education	*N*	%
Missing	*1*	.1%
On the job training	*3*	.4%
BS Civil/Structural/Architecture Engineering	*285*	39.6%
BS in another field	*6*	.8%
MS/PHD Civil Engineering	*75*	10.4%
MS/PHD Structural Engineering	*330*	45.9%
MS/PHD Other Engineering	*6*	.8%
MS/PHD another field	*11*	1.5%
Other	*2*	.3%
Total	*719*	100.0%

[a] Registered engineers only [b] Highest educational achievement [c] Choose all that apply

Table 8.12e. Bachelor's Degree Program for Manufacturing and Metallurgical Engineers

	Manufacturing[b]		Metallurgical[b]	
Which best describes Bachelor's?	*N*	%	*N*	%
Missing	*52*	9.5%	*4*	2.1%
Aeronautical/Aerospace Engineering	*12*	2.2%		
Agricultural Engineering	*7*	1.3%		
Chemical Engineering	*7*	1.3%	*16*	8.6%
Civil Engineering	*7*	1.3%	*2*	1.1%
Computer Engineering	*1*	.2%		
Electrical Engineering	*39*	7.1%		
Engineering Management	*6*	1.1%		
Engineering Mechanics	*10*	1.8%	*4*	2.1%
Engineering Physics/Engineering Science	*11*	2.0%	*5*	2.7%
Forest Engineering	*1*	.2%		
General Engineering	*3*	.6%	*1*	.5%
Industrial Engineering	*54*	9.9%		
Manufacturing Engineering	*45*	8.2%		
Materials Engineering	*3*	.6%	*16*	8.6%
Mechanical Engineering	*255*	46.5%	*12*	6.4%
Metallurgical Engineering	*19*	3.5%	*123*	65.8%
Naval Architecture & Marine Engineering	*2*	.4%		
Systems Engineering	*1*	.2%		
Welding Engineering	*2*	.4%		
Other	*11*	2.0%	*4*	2.1%
Total	*548*	100.0%	*183*	100.0%

Table 8.12f. Specialty of Highest Engineering Degree for Control Systems Engineers

	Control Systems	
Specialty of Highest Engineering Degree	*N*	%
Chemical	*116*	14.2%
Civil	*16*	2.0%
Control Systems	*75*	9.2%
Electrical	*344*	42.2%
Mechanical	*172*	21.1%
Other	*62*	7.6%
Did not respond	*31*	3.8%
Total	*816*	100.0%

Table 8.13: Job Analysis Report Information on ABET Accredited Programs
Bachelor's degree from ABET accredited program

	Agricultural		Chemical*		Civil		Electrical		Industrial		Manufacturing		Mechanical		Metallurgical		Petroleum	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Missing	3	0.3%	1	0.4%	2	0.3%	118	6.5%			28	5.1%	56	3.3%			71	28.6%
Yes	851	89.9%	181	79.7%	538	76.9%	1546	85.7%	143	70.1%	356	65.0%	1514	88.3%	152	81.3%	148	59.7%
No	40	4.2%	5	2.2%	41	5.9%	41	2.3%	11	5.4%	40	7.3%	32	1.9%	11	5.9%	20	8.1%
DK	37	3.9%	38	16.7%	110	15.7%	99	5.5%	42	20.6%	100	18.3%	103	6.0%	24	12.8%	9	3.6%
No bachelor's degree	16	1.7%	2	0.9%	9	1.3%			8	3.9%	24	4.4%	8	0.5%				
Total	947	100.0%	227	99.9%	700	100.0%	1804	100.0%	204	100.0%	548	100.0%	1713	100.0%	187	100.0%	248	100.0%

* ECPD/ABET
No information in Control Systems, Geotechnical, Nuclear, Structural, or Traffic Engineering Job Analysis Reports